UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Chemical analyses of coal from the Krebs Group (Pennsylvanian), Arkoma basin, eastern Oklahoma

by

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This report is preliminary and has not been edited
or reviewed for conformity with
U.S. Geological Survey standards.

Introduction

Coal-bearing rocks underlie 19 counties in eastern Oklahoma, an area of approximately 2,395 square miles. Recent estimates of bituminous coal resources in eastern Oklahoma (Friedman, 1975) show that 7.1 billion short tons of bituminous coal are present in beds 14 inches or more in thickness under less than 3,000 feet of overburden. Included as part of these identified resources is a coal reserve base of 1.3 billion short tons (Averitt, 1975). These are coal beds 28 inches or more in thickness to depths as great as 1,000 feet.

The coal resources of interest in this report lie within the boundaries of the Arkoma basin, a structural basin underlain by faulted and broadly folded Pennsylvanian strata. The counties within the Arkoma basin containing significant coal resources from which samples were collected are Haskell (1,513,681,000 short tons), Latimer (841,968,000 short tons), LeFlore (1,973,362,000 short tons), and Pittsburg (1,383,833,000 short tons) (Friedman, 1975). The locations of sample sites in the Arkoma basin are shown in figures 1 and 2.

Significant to any complete coal resource appraisal is an estimate of the chemical composition of the coal. Four somewhat overlapping reasons for obtaining comprehensive and precise chemical analyses of coal are as follows: (1) to help assess the environmental implications of coal mining and utilization, (2) to help determine the most suitable use of the coal, (3) to assess possible by-product recovery, and (4) to help interpret the geological and geochemical history of the coal-bearing rocks (Hatch and Swanson, 1977).

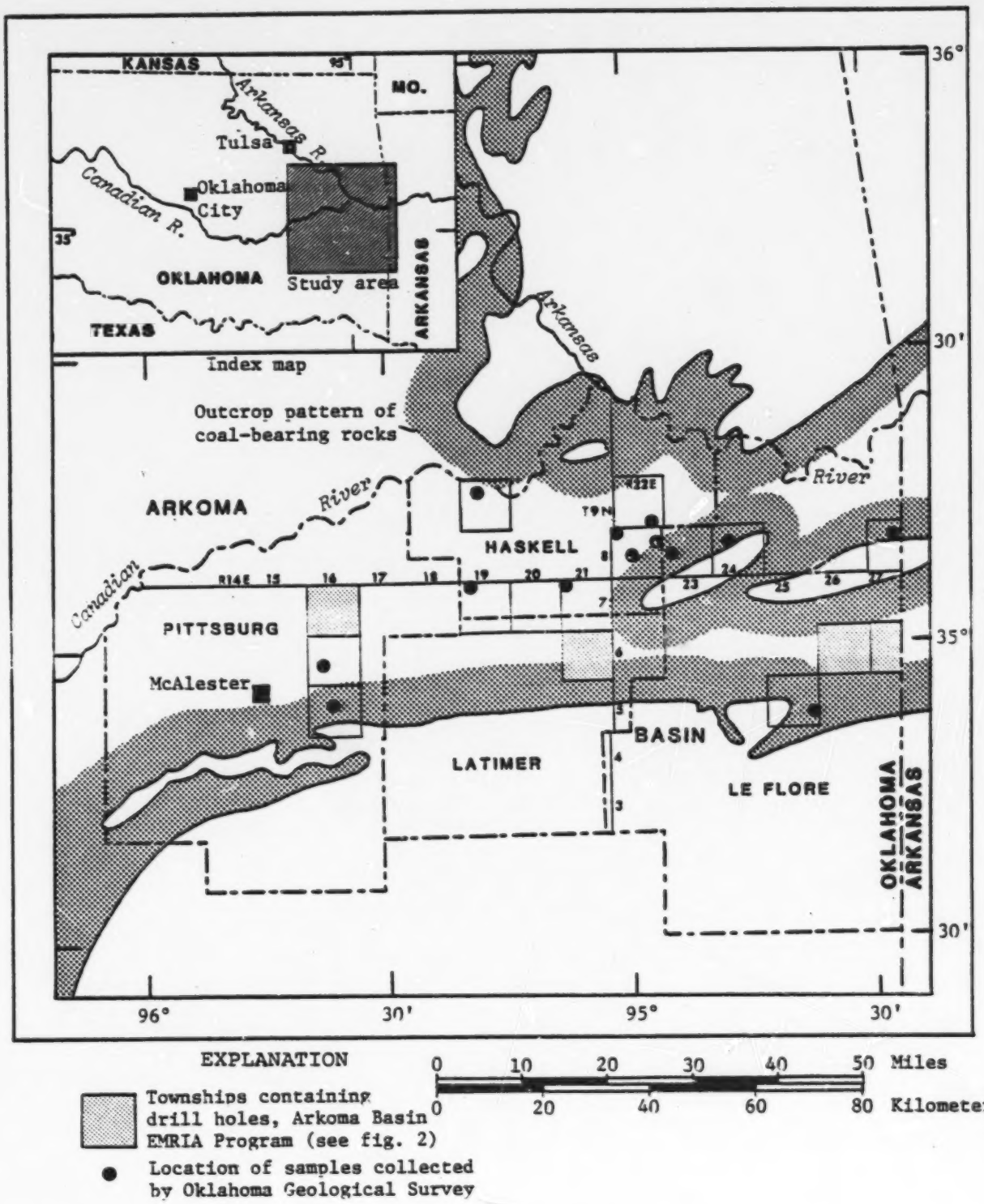
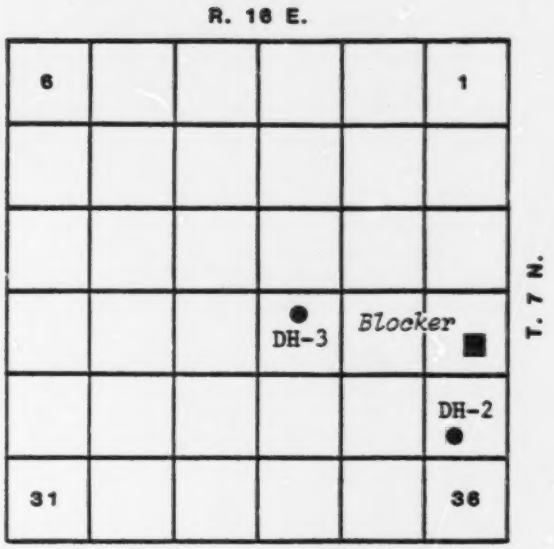
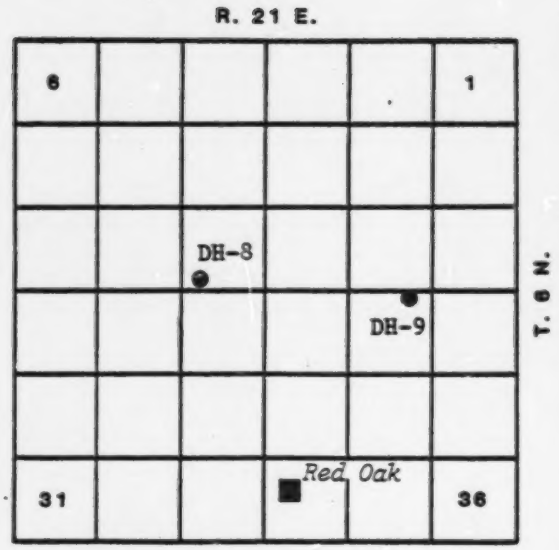


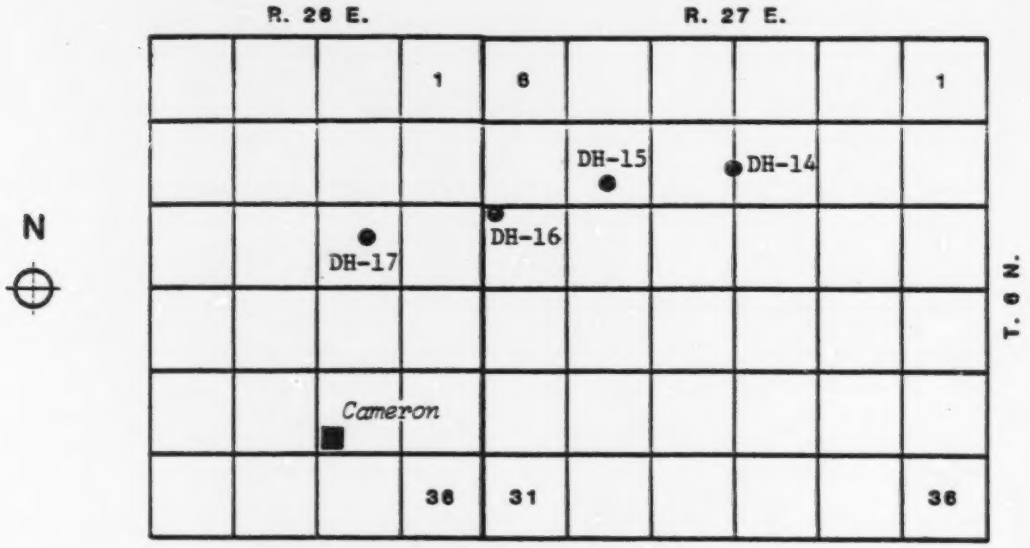
Figure 1.—Map showing locations of sample sites, Arkoma basin, eastern Oklahoma (modified from AAPG Highway Map Committee, 1966).



Locations of drill holes 2 & 3
Blocker 7.5' quad, Pittsburg Co.



Locations of drill holes 8 & 9
Red Oak 15' quad, Latimer Co.



Locations of drill holes 14 - 17
Hackett and Spiro 7.5' quads, LeFlore Co.

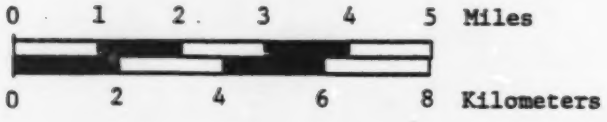


Figure 2.--Locations of sampled drill holes, Arkoma Basin EMRIA Program, eastern Oklahoma.

A total of 51 samples of coal were collected from the Arkoma basin, including 39 samples collected from several active mines by the Oklahoma Geological Survey (table 1) and 12 samples collected from eight EMRIA drill holes (table 2). These samples represent six principal coal beds in the Krebs Group of Middle Pennsylvanian (Des Moinesian) age. Figure 3 shows the general stratigraphy of formations and coal beds in the Krebs Group.

More detailed information on the general geology and stratigraphy of coal-bearing strata in eastern Oklahoma is included in Trumbull (1957), Johnson and others (1972), and Friedman (1975). Additional studies on trace elements in coal in the Arkoma basin and vicinity are included in Zubovic and others (1967), Boerngen and others (1975), and Swanson and others (1976).

Explanation of data and summary tables

Proximate and ultimate analyses, heat-of-combustion, air-dried-loss, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 30 single and composite coal samples from the Arkoma basin, eastern Oklahoma, are given in table 3. These analyses were provided by the Coal Analysis Section, Department of Energy (formerly U.S. Bureau of Mines), Pittsburgh, Pa. Analyses for ash content, contents of 36 major and minor oxides and trace elements in the laboratory ash (table 4), and analyses of seven trace elements in whole coal (table 5) for 51 coal samples from the Arkoma basin were provided by the U.S. Geological Survey in Denver, Colo. Table 6 contains the data listed in table 4 converted to a whole-coal basis and includes the whole-coal analyses listed in table 5. Twenty-two additional elements not listed in tables 4, 5, and 6 were looked for but not found in amounts greater than their lower limit of detection (table 7).

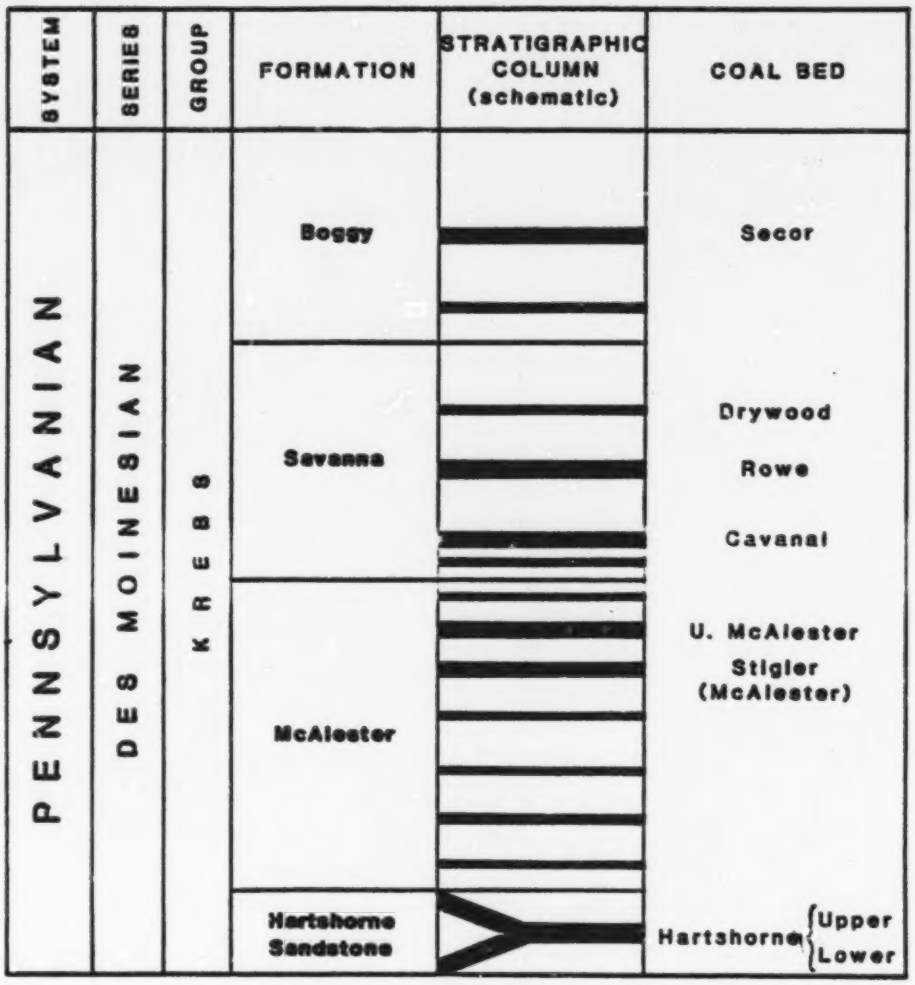


Figure 3.--Generalized stratigraphic column showing sequence of coal beds, Krebs Group, Arkoma basin, eastern Oklahoma (modified from Friedman, 1975).

Unweighted statistical summaries of the analytical data in tables 3, 4, and 6 are summarized in tables 8, 9, and 10. Data summaries for P_2O_5 content in ash, and Ag, Cd, Ce, Ge, La, Nd, P, and Th contents in whole coal are not included in tables 9 and 10 because these elements were detected in an insufficient number of samples to calculate meaningful statistics.

Most of the analytical procedures used by the U.S. Geological Survey are described in Swanson and Huffman (1976). Arsenic contents of samples summarized in this report have been determined by three different analytical methods: samples D176165 - D176854 were analyzed spectrophotometrically (lower detection limit 1.0 ppm); samples D179902 - D179910 were analyzed by the graphite furnace-atomic absorption method (lower detection limit 0.5 ppm); the remaining 11 samples were analyzed by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

Antimony, selenium, and thorium contents of samples D176165 - D179910 were determined by the Rhodamine-B spectrophotometric method (lower detection limit 0.1 ppm), x-ray fluorescence analysis (lower detection limit 0.1 ppm), and delayed neutron activation analysis (lower detection limit 3.0 ppm), respectively. The remaining 11 samples were analyzed for antimony, selenium, and thorium by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

To be consistent with the precision of the semiquantitative emission spectrographic technique, arithmetic and geometric means of elements determined by this method are reported as the midpoint of the enclosing six-step brackets. (See headnote of table 4 or Swanson and Huffman, 1976, p. 6, for an explanation of six-step brackets). The typical procedure for sample preparation and analysis used by the U.S. Geological Survey is shown in figure 4.

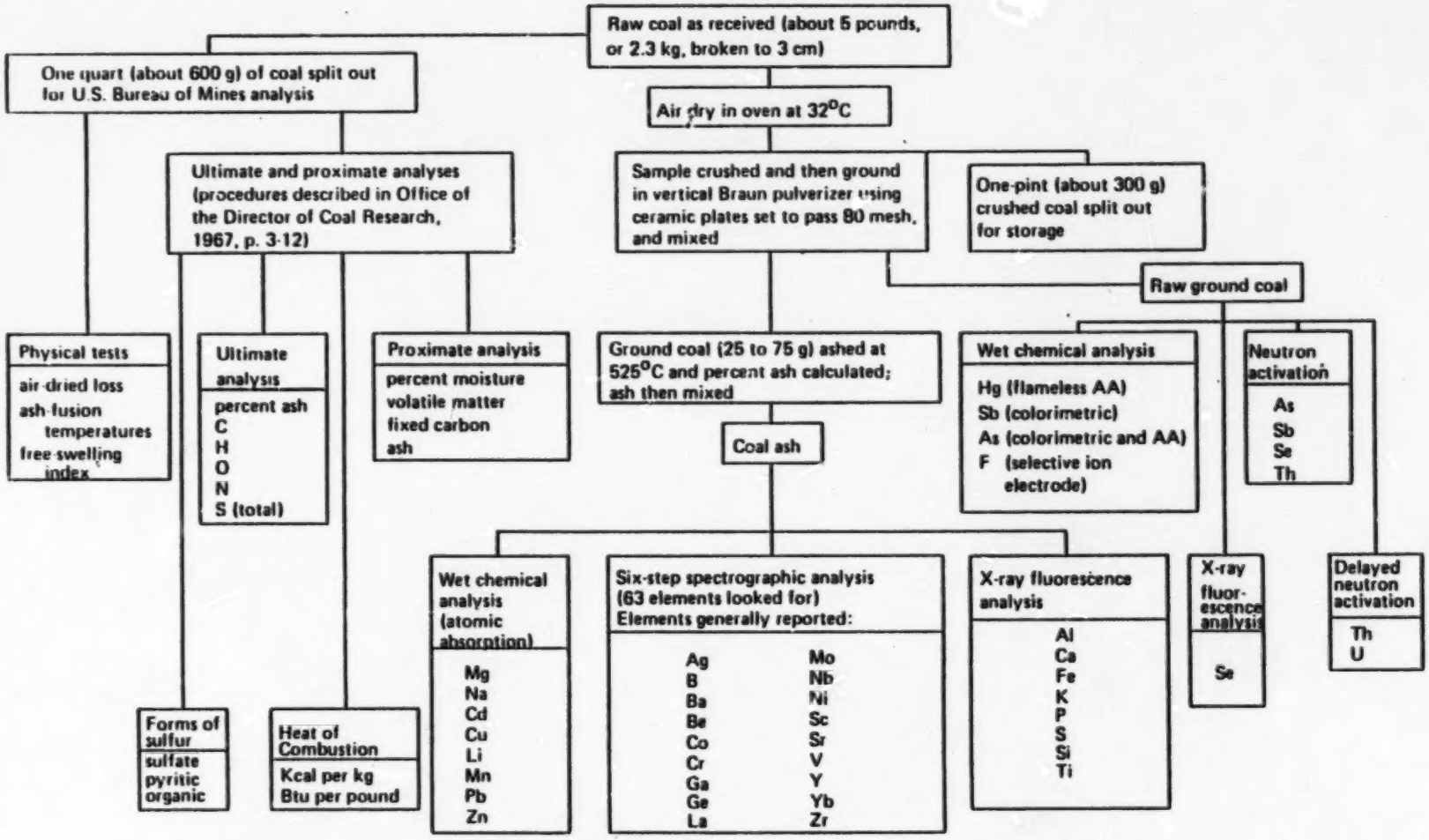


Figure 4.--Flow chart showing sequence of sample preparation and chemical analysis (modified from Swanson and Huffman, 1976).

Explanation of statistical terms used in summary tables

In this report the geometric mean (GM) is used as the estimate of the most probable concentration (mode). The GM is calculated by taking the logarithm of each analytical value, summing the logarithms, dividing the sum by the total number of values, and obtaining the antilogarithm of the result. The measure of scatter about the mode used here is the geometric deviation (GD), which is the antilog of the standard deviation of the logarithms of the analytical values. These statistics are used because the quantities of trace elements in natural distributions are normalized by statistically analyzing and summarizing trace-element data on a logarithmic basis.

If the frequency distributions are lognormal, the GM is the best estimate of the mode, and the estimated range of the central two-thirds of the observed distribution has a lower limit equal to GM/GD and an upper limit equal to GM x GD. The estimated range of the central 95 percent of the observed distribution has a lower limit equal to $GM/(GD)^2$ and an upper limit equal to $GM \times (GD)^2$ (Connor and others, 1976).

Although the geometric mean is, in general, an adequate estimate of the most common analytical value, it is, nevertheless, a biased estimate of the arithmetic mean. The estimates of the arithmetic means listed in the summary tables are Sichel's $\underline{t}$ statistic (Miesch, 1967).

A common problem in statistical summaries of trace-element data arises when the element content of one or more samples is below the limit of analytical detection. This results in a "censored" distribution. Procedures developed by Cohen (1959) are used to compute biased estimates of the GM, GD, and arithmetic mean when the data are censored.

Discussion

The apparent ranks for 29 samples from the Arkoma basin were calculated using the data in table 3 and the formulae in ASTM designation D-388-77 (American Society for Testing and Materials, 1978). The heat of combustion (moist, mineral-matter free basis) for the samples from the Arkoma basin ranges from 14,200 Btu/lb (7,930 kcal/kg) to 15,620 Btu/lb (8,680 kcal/kg); the fixed carbon (dry, mineral-matter free basis) ranges from 55.9 percent to 81.9 percent. The distribution of apparent rank for the samples is as follows: high-volatile A bituminous coal—13 samples; medium-volatile coal—5 samples; and low-volatile bituminous coal—11 samples. The free-swelling index for the samples ranges from 1.0 to 9.0. Apparent rank and free-swelling index were not included for sample D223850 because of the high ash content.

Statistical comparisons, using the "t" and "f" tests (95-percent confidence) (Miller and Kahn, 1962), of the sample means and variances for the U.S. Department of Energy data for 30 samples from the Arkoma basin with 90 Interior Province coal samples (Swanson and others, 1976) show that the Arkoma basin samples collectively have significantly higher contents of fixed carbon, carbon, and nitrogen, a significantly higher heat of combustion, and significantly lower contents of moisture, volatile matter, hydrogen, oxygen, sulfur, and pyritic and organic sulfur. Contents of ash and sulfate sulfur are not significantly different.

Statistical comparisons of sample means and variances of coal ash and nine major and minor oxides in ash for 51 Arkoma basin samples with 155 Interior Province coal samples (Hatch and Swanson, 1977) show that the Arkoma basin samples collectively have a significantly lower ash content, significantly lower content of Fe_2O_3 in ash, and significantly higher contents of Al_2O_3, MgO, Na_2O, and K_2O in ash. Contents of SiO_2, CaO, TiO_2, and SO_3 in ash are not significantly different.

Statistical comparisons of sample means and variances of 34 elements (whole-coal basis) for 51 Arkoma basin samples with 155 Interior Province coal samples (Hatch and Swanson, 1977) show that the Arkoma basin samples collectively have significantly higher contents of Mg, Ba, Mo, Nb, and Sr, and significantly lower contents of Fe, B, Be, Co, Cu, N, Pb, Sb, Sc, Se, U, and Zn. Contents of Si, Al, Ca, Na, K, Ti, As, Cr, F, Ga, Hg, Li, Mn, V, Y, Yb, and Zr are not significantly different.

Differences in the oxide composition of coal ash and the element contents of coal result from differences in the total and relative amounts of the various minerals in the coal, and the total and relative amounts of organically bound elements. The chemical form and distribution of a given element are dependent on the geologic history of the coal bed. A partial listing of the geologic factors that influence element distributions includes chemical composition of original plants; amounts and compositions of various detrital, diagenetic, and epigenetic minerals; temperatures and pressures during burial; and extent of weathering. No evaluation of these factors has been made for any of the coal beds in the Arkoma basin.

Compared to coal from the Interior province (Swanson and others, 1976), coal in the Arkoma basin is generally characterized by low ash, low sulfur, high fixed carbon, and high heat content. The contents of trace elements, particularly Be, Pb, Sb, Se, and Zn, are generally low in coal from the Arkoma basin when compared collectively to coal from the Interior province (Hatch and Swanson, 1977).

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TABLES 1-10

Table 1.--U.S. Geological Survey sample numbers, mine names, locations, bed names, sample types, and sample thicknesses for 39 bituminous coal samples from the Krebs Group, Arkoma basin, Oklahoma

[All samples collected by the Oklahoma Geological Survey]

USGS sample number	Mine name (or operator)	Location			Coal bed name	Sample type	Sample thickness (feet)
		Section	Township N.	Range E.			
			Pittsburg County				
D183440	4 Star Coal & Mining Co. No. 3	21	6	16	Secor	Bench channel	Upper 1.17
D183439	-----do-----	21	6	16	--do--	-----do-----	next 0.79
D183438	-----do-----	21	6	16	--do--	-----do-----	next 0.62
D183437	-----do-----	21	6	16	--do--	-----do-----	lower 0.44
D179904	Pocahontas	16	5	16	U.Hartshorne	Face channel	1.20
D179906	-----do-----	16	5	16	L.Hartshorne	Bench channel	Upper 1.00
D179905	-----do-----	16	5	16	--do--	-----do-----	Lower 3.45
			Haskell County				
D176167	Keota Coal Co.	35	9	22	Stigler	Face channel	1.54
D176168	-----do-----	35	9	22	--do--	-----do-----	1.54
D179910	Lewisville No. 1	5	7	19	--do--	Bench channel	Upper 1.59
D179909	-----do-----	5	7	19	--do--	-----do-----	Lower 0.24
D183424	Hoyt	9	9	19	--do--	Face channel	2.10
D183436	Garland	6	7	21	--do--	Bench channel	Upper 0.23
D183435	-----do-----	6	7	21	--do--	-----do-----	Middle 0.70
D183434	-----do-----	6	7	21	--do--	-----do-----	Lower 1.00
D176851	Great National-McCurtain #2	13	8	22	U.Hartshorne	Face channel	2.36
D176852	-----do-----	13	8	22	--do--	-----do-----	2.36
D179908	-----do-----	13	8	22	--do-	Bench channel	1.50
D179907	-----do-----	13	8	22	--do--	-----do-----	Lower 1.15
D176853	-----do-----	13	8	22	L.Hartshorne	Face channel	2.50
D176854	-----do-----	13	8	22	--do--	-----do-----	2.50
D179903	Great National-Karst	22	8	22	--do--	Bench channel	1.40
D179902	-----do-----	22	8	22	--do--	-----do-----	Lower 2.50

Table 1.--U.S. Geological Survey sample numbers, mine names, locations, bed names, sample types, and sample thicknesses for 39 bituminous coal samples from the Krebs Group, Arkoma basin, Oklahoma--continued

USGS sample number	Mine name (or operator)	Location			Coal Bed name	Sample type	Sample thickness (feet)
		Section	Township N.	Range E.			
			Haskell County--continued				
D176848	Kerr-McGee-Choctaw	6	8	22	Hartshorne	Face channel	4.01
D176849	-----do-----	6	8	22	--do--	-----do-----	4.01
			LeFlore County				
D176244	Garland #10	16	8	24	U.Hartshorne	Face channel	3.30
D176245	-----do-----	16	8	24	--do--	-----do-----	3.30
D176246	-----do-----	16	8	24	--do--	-----do-----	3.30
D176248	Mullen	20	8	23	--do--	-----do-----	2.63
D183433	Paul Rees-Heavener	25	5	25	--do--	Bench channel	Upper 0.33
D183432	-----do-----	25	5	25	--do--	-----do-----	Middle 0.83
D183431	-----do-----	25	5	25	--do--	-----do-----	Lower 0.83
D176165	Garland #10	16	8	24	L.Hartshorne	Face channel	3.27
D176166	-----do-----	16	8	24	--do--	-----do-----	3.27
D176249	Mullen	20	8	23	--do--	-----do-----	3.50
D176250	Farrell Cooper	10	8	27	Hartshorne	-----do-----	3.56
D176251	-----do-----	10	8	27	--do--	-----do-----	3.56
D176252	-----do-----	10	8	27	--do--	-----do-----	3.56
D176850	Mullen	20	8	23	--do--	-----do-----	0.40

Table 2.--U.S. Geological Survey sample numbers, hole numbers, locations, and depth intervals for 12 bituminous coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[All samples collected during the Arkoma Basin EMRIA Program]

USGS sample number	Hole number	Location			Coal bed name (tentative)	Depth interval (feet)
		Section	Township N.	Range E.		
Pittsburg County						
D223841	DH-2	25	7	16	Secor	75.4-76.6
D223842	DH-2	25	7	16	uncorrelated	112.6-115.0
D223843	DH-3	22	7	16	Secor	42.4-45.2
D223844	DH-3	22	7	16	uncorrelated	142.6-143.6
D223845	DH-3	22	7	16	----do----	174.6-175.7
Latimer County						
D223846	DH-8	16	6	21	Upper McAlester	36.4-38.3
D223847	DH-8	16	6	21	Stigler	104.0-106.8
D223848	DH-9	23	6	21	----do----	133.9-135.9
LeFlore County						
D223849	DH-14	9	6	26	Upper Hartshorne	87.2-89.6
D223850	DH-15	8	6	26	----do----	57.1-59.7
D223851	DH-16	18	6	26	Lower Hartshorne	184.5-188.6
D223852	DH-17	14	6	27	----do----	191.6-194.5

Table 3.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 30 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[All analyses except kcal/kg, Btu/lb, free-swelling index (FSI), and ash-fusion temperatures in percent. For each sample number, the analyses are reported three ways: first, as received; second, moisture free; third, moisture and ash free. Kcal/kg = 0.556 x (Btu/lb); °F = (°C x 1.8) + 32. D183437* is a composite of samples D183437, D183438, D183439, and D183440; D179905* is a composite of D179905 and D179906; D176167* is a composite of D176167 and D176168; D179909* is a composite of D179909 and D179910; D183434* is a composite of D183434, D183435, and D183436; D176851* is a composite of D176851 and D176852; D179907* is a composite of D179907 and D179908; D176853* is a composite of D176853 and D176854; D179902* is a composite of D179902 and D179903; D176848* is a composite of D176848 and D176849; D176244* is a composite of D176244, D176245, and D176246; D183431* is a composite of D183431, D183432, and D183433; D176165* is a composite of D176165 and D176166; D176250* is a composite of D176250, D176251, and D176252]

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D183437*	1.9	38.9	48.3	10.9	5.0	70.0	1.5	6.7	5.8	7,170	12,910
	---	39.7	49.2	11.1	4.9	71.4	1.5	5.1	5.9	7,310	13,160
	---	44.6	55.4	---	5.5	80.3	1.7	5.7	6.7	8,230	14,810
D179904	2.9	29.5	44.8	22.8	4.4	59.4	1.7	9.6	2.0	5,920	10,660
	---	30.4	46.1	23.5	4.2	61.2	1.8	7.2	2.1	6,100	10,980
	---	39.7	60.3	---	5.5	79.9	2.3	9.5	2.7	7,970	14,340
D179905*	2.6	32.1	55.6	9.7	5.2	72.5	2.1	8.9	1.6	7,200	12,970
	---	33.0	57.1	10.0	5.0	74.4	2.2	6.8	1.6	7,400	13,310
	---	36.6	63.4	---	5.6	82.7	2.4	7.5	1.8	8,210	14,790
D176167*	1.8	24.7	63.3	10.2	4.7	76.8	1.7	5.0	1.6	7,520	13,540
	---	25.2	64.5	10.4	4.6	78.2	1.7	3.5	1.6	7,660	13,790
	---	28.1	71.9	---	5.1	87.3	1.9	3.9	1.8	8,550	15,390
D179909*	1.9	30.5	60.5	7.1	5.2	77.6	1.9	6.6	1.6	7,690	13,840
	---	31.1	61.7	7.2	5.1	79.1	1.9	5.0	1.6	7,840	14,100
	---	33.5	66.5	---	5.5	85.3	2.1	5.4	1.8	8,450	15,210
D183424	1.8	28.4	61.5	8.3	5.1	76.4	1.9	6.8	1.5	7,600	13,690
	---	28.9	62.6	8.5	5.0	77.8	1.9	5.3	1.5	7,740	13,940
	---	31.6	68.4	---	5.5	85.0	2.1	5.8	1.7	8,460	15,220
D183434*	2.6	30.8	62.1	4.5	5.2	79.9	1.8	7.1	1.6	7,960	14,330
	---	31.6	63.8	4.6	5.0	82.0	1.8	4.9	1.6	8,180	14,720
	---	33.2	66.8	---	5.3	86.0	1.9	5.2	1.7	8,570	15,430
D176851*	1.0	21.4	74.4	3.2	4.8	85.7	1.9	3.9	.5	8,290	14,930
	---	21.6	75.2	3.2	4.7	86.6	1.9	3.0	.5	8,380	15,080
	---	22.3	77.7	---	4.9	89.5	2.0	3.1	.5	8,660	15,580
D179907*	1.6	20.3	75.5	2.6	4.7	85.6	1.8	4.4	.7	8,310	14,960
	---	20.6	76.7	2.6	4.6	87.0	1.8	3.0	.7	8,450	15,210
	---	21.2	78.8	---	4.7	89.4	1.9	3.1	.7	8,680	15,620
D176853*	2.8	19.6	74.1	3.5	4.7	83.8	1.7	5.8	.5	8,090	14,560
	---	20.2	76.2	3.6	4.5	86.2	1.7	3.4	.5	8,320	14,980
	---	20.9	79.1	---	4.7	89.4	1.8	3.5	.5	8,630	15,540
D179902*	1.2	20.4	74.9	3.5	4.7	84.7	1.9	4.5	.8	8,260	14,860
	---	20.6	75.8	3.5	4.6	85.7	1.9	3.5	.8	8,360	15,040
	---	21.4	78.6	---	4.8	88.9	2.0	3.6	.8	8,660	15,590
D176848*	1.2	19.3	73.9	5.6	4.4	83.0	1.8	4.4	.8	7,960	14,320
	---	19.5	74.8	5.7	4.3	84.0	1.8	3.4	.8	8,050	14,490
	---	20.7	79.3	---	4.6	89.1	1.9	3.6	.9	8,540	15,360

Table 3.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 30 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D183437*	0.3	0.18	3.20	2.42	7.5	1,130	1,180	1,245
	---	.18	3.26	2.47				
	---	.21	3.67	2.78				
D179904	1.0	.30	1.08	.63	1.5	1,445	1,500	1,540
	---	.31	1.11	.65				
	---	.40	1.45	.85				
D179905*	.9	.28	.78	.58	6.0	1,145	1,200	1,245
	---	.29	.80	.60				
	---	.32	.89	.66				
D176167*	.9	.14	.82	.59	9.0	1,210	1,320	1,390
	---	.14	.84	.60				
	---	.16	.93	.67				
D179909*	.5	.18	1.22	.19	9.0	1,070	1,115	1,140
	---	.18	1.24	.19				
	---	.20	1.34	.21				
D183424	.2	.16	.64	.68	2.5	1,165	1,225	1,280
	---	.16	.65	.69				
	---	.18	.71	.76				
D183434*	1.2	.24	.79	.54	9.0	1,065	1,130	1,175
	---	.25	.81	.55				
	---	.26	.85	.58				
D176851*	.4	.06	.10	.38	9.0	1,090	1,115	1,145
	---	.06	.10	.38				
	---	.06	.10	.40				
D179907*	1.0	.12	.07	.54	9.0	1,200	1,250	1,305
	---	.12	.07	.55				
	---	.13	.07	.56				
D176853*	1.9	.08	.03	.43	9.0	1,205	1,260	1,360
	---	.08	.03	.44				
	---	.09	.03	.46				
D179902*	.6	.16	.15	.50	9.0	1,215	1,260	1,365
	---	.16	.15	.51				
	---	.17	.16	.52				
D176848*	.4	.06	.27	.48	6.0	1,115	1,145	1,170
	---	.06	.27	.49				
	---	.06	.29	.52				

Table 3.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 30 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D176244*	4.9	20.7	62.8	11.6	3.4	73.7	1.6	7.8	1.9	6,990	12,590
	---	21.8	66.0	12.2	3.0	77.5	1.7	3.6	2.0	7,350	13,240
	---	24.8	75.2	---	3.4	88.3	1.9	4.1	2.3	8,380	15,080
D176248	3.0	18.4	72.5	6.1	4.5	79.8	1.6	5.3	2.7	7,710	13,880
	---	19.0	74.7	6.3	4.3	82.3	1.6	2.7	2.8	7,950	14,310
	---	20.2	79.8	---	4.6	87.8	1.8	2.9	3.0	8,480	15,270
D183431*	1.0	22.0	68.5	8.5	4.5	80.5	1.7	3.9	1.0	7,860	14,140
	---	22.2	69.2	8.6	4.4	81.3	1.7	3.0	1.0	7,940	14,280
	---	24.3	75.7	---	4.8	89.0	1.9	3.3	1.1	8,680	15,630
D176165*	3.5	18.1	70.1	8.3	4.4	78.8	1.7	5.7	1.1	7,440	13,400
	---	18.8	72.6	8.6	4.2	81.7	1.8	2.7	1.1	7,710	13,890
	---	20.5	79.5	---	4.5	89.3	1.9	2.9	1.2	8,440	15,190
D176249	2.9	18.7	73.5	4.9	4.6	80.9	1.7	5.7	2.2	7,850	14,130
	---	19.3	75.7	5.0	4.4	83.3	1.8	3.2	2.3	8,080	14,550
	---	20.3	79.7	---	4.6	87.7	1.8	3.4	2.4	8,510	15,330
D176250*	2.5	16.5	67.7	13.3	4.2	74.7	1.7	4.3	1.8	7,140	12,850
	---	16.9	69.4	13.6	4.0	76.6	1.7	2.1	1.8	7,320	13,180
	---	19.6	80.4	---	4.7	88.7	2.0	2.5	2.1	8,480	15,260
D223841	1.9	37.2	43.8	17.1	4.7	64.2	1.5	3.5	9.1	6,670	12,010
	---	37.9	44.6	17.4	4.6	65.4	1.5	1.8	9.3	6,800	12,240
	---	45.9	54.1	---	5.5	79.3	1.9	2.2	11.2	8,240	14,820
D223842	1.9	37.1	45.2	15.8	4.9	66.4	1.5	4.5	6.9	6,850	12,330
	---	37.8	46.1	16.1	4.8	67.7	1.5	2.9	7.0	6,980	12,570
	---	45.1	54.9	---	5.7	80.7	1.8	3.4	8.4	8,320	14,980
D223843	2.0	38.1	46.5	13.4	5.1	68.3	1.5	4.9	6.8	7,060	12,700
	---	38.9	47.4	13.7	5.0	69.7	1.5	3.2	6.9	7,200	12,960
	---	45.0	55.0	---	5.8	80.7	1.8	3.7	8.0	8,340	15,010
D223844	2.3	30.4	41.5	25.8	4.4	58.3	1.5	7.4	2.6	5,850	10,520
	---	31.1	42.5	26.4	4.2	59.7	1.5	5.5	2.7	5,980	10,770
	---	42.3	57.7	---	5.8	81.1	2.1	7.4	3.6	8,130	14,640
D223845	1.9	34.8	45.2	18.1	4.9	66.0	1.7	7.1	2.2	6,630	11,940
	---	35.5	46.1	18.5	4.8	67.3	1.7	5.5	2.2	6,760	12,170
	---	43.5	56.5	---	5.9	82.5	2.1	6.8	2.7	8,290	14,930
D223846	1.9	35.4	46.5	16.2	4.8	67.6	1.5	4.2	5.7	6,870	12,360
	---	36.1	47.4	16.5	4.7	68.9	1.5	2.6	5.8	7,000	12,600
	---	43.2	56.8	---	5.6	82.5	1.8	3.1	7.0	8,390	15,100

Table 3.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 30 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D176244*	4.2	0.15	1.02	0.73	4.5	1,150	1,175	1,205
	---	.16	1.07	.77				
	---	.18	1.22	.87				
D176248	2.0	.49	1.28	.92	8.0	1,095	1,120	1,150
	---	.51	1.32	.95				
	---	.54	1.41	1.01				
D183431*	.4	.07	.48	.43	9.0	1,100	1,155	1,210
	---	.07	.48	.43				
	---	.08	.53	.48				
D176165*	2.7	.05	.40	.61	7.5	1,260	1,290	1,315
	---	.05	.41	.63				
	---	.06	.45	.69				
D176249	1.9	.34	1.22	.66	8.5	1,080	1,110	1,140
	---	.35	1.26	.68				
	---	.37	1.32	.72				
D176250*	1.5	.18	.91	.70	4.0	1,290	1,345	1,465
	---	.18	.93	.72				
	---	.21	1.08	.83				
D223841	.8	.04	7.26	1.77	8.0	1,075	1,160	1,220
	---	.04	7.40	1.80				
	---	.05	8.96	2.19				
D223842	.7	.19	5.13	1.62	7.5	965	1,040	1,075
	---	.19	5.23	1.65				
	---	.23	6.23	1.97				
D223843	.9	.14	5.00	1.62	8.0	1,150	1,205	1,250
	---	.14	5.10	1.65				
	---	.17	5.91	1.91				
D223844	.9	.04	2.01	.55	8.0	1,020	1,110	1,195
	---	.04	2.06	.56				
	---	.06	2.80	.76				
D223845	.7	.01	1.57	.60	7.5	1,180	1,225	1,260
	---	.01	1.60	.61				
	---	.01	1.96	.75				
D223846	.7	.36	4.32	1.04	8.5	1,140	1,175	1,215
	---	.37	4.40	1.06				
	---	.44	5.27	1.27				

Table 3.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 30 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D223847	2.4	33.3	46.6	17.7	4.8	66.4	1.5	6.0	3.8	6,660	12,000
	---	34.1	47.7	18.1	4.6	68.0	1.5	4.0	3.9	6,830	12,290
	---	41.7	58.3	---	5.7	83.1	1.9	4.8	4.8	8,340	15,010
D223848	2.1	32.7	51.5	13.7	4.9	70.9	1.5	4.4	4.7	7,100	12,790
	---	33.4	52.6	14.0	4.8	72.4	1.5	2.6	4.8	7,260	13,060
	---	38.8	61.2	---	5.5	84.2	1.8	3.0	5.6	8,440	15,190
D223849	1.7	15.3	55.9	27.1	3.7	61.6	1.4	5.0	1.1	5,940	10,700
	---	15.6	56.9	27.6	3.6	62.7	1.4	3.5	1.1	6,050	10,880
	---	21.5	78.5	---	4.9	86.5	2.0	4.9	1.5	8,350	15,030
D223850	2.1	13.9	28.0	56.0	2.7	33.2	.7	6.6	.8	3,120	5,620
	---	14.2	28.6	57.2	2.5	33.9	.7	4.8	.8	3,190	5,740
	---	33.2	66.8	---	5.9	79.2	1.7	11.3	1.9	7,450	13,420
D223851	1.2	18.0	64.4	16.4	4.0	73.5	1.5	3.2	1.3	7,070	12,730
	---	18.2	65.2	16.6	3.9	74.4	1.5	2.2	1.3	7,160	12,890
	---	21.8	78.2	---	4.7	89.2	1.8	2.6	1.6	8,590	15,460
D223852	1.3	17.9	69.0	11.8	4.2	78.7	1.6	2.2	1.6	7,500	13,500
	---	18.1	69.9	12.0	4.1	79.7	1.6	1.1	1.6	7,600	13,680
	---	20.6	79.4	---	4.7	90.6	1.8	1.2	1.8	8,630	15,540

Table 3.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 30 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D223847	1.0	0.25	2.70	0.81	8.5	1,060	1,105	1,145
	---	.26	2.77	.83				
	---	.31	3.38	1.01				
D223848	.8	.35	3.24	1.08	9.0	1,175	1,220	1,260
	---	.36	3.31	1.10				
	---	.42	3.85	1.28				
D223849	.7	.02	.74	.33	2.0	1,540+	1,540+	1,540+
	---	.02	.75	.34				
	---	.03	1.04	.46				
D223850	.6	.02	.69	.07	1.0	1,540+	1,540+	1,540+
	---	.02	.70	.07				
	---	.05	1.65	.17				
D223851	.6	.03	.72	.52	6.5	1,205	1,270	1,315
	---	.03	.73	.53				
	---	.04	.87	.63				
D223852	.7	.01	.92	.68	5.5	1,140	1,180	1,225
	---	.01	.93	.69				
	---	.01	1.06	.78				

Table 4.—Major- and minor-oxide and trace-element composition of the laboratory ash of 31 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[Coal ashed at 525°C. L means less than the value shown; N, not detected; B, not determined. S after the element title indicates determinations by semiquantitative emission spectrography. The spectrographic results are to be identified with geometric brackets whose boundaries are part of the ascending series 0.12, 0.18, 0.26, 0.38, 0,56, 0.83, 1.2, etc., but reported as midpoints of the brackets, 0.1, 0.15, 0.2, 0.3, 0.5, 0.7, 1.0, etc.; precision of the spectrographic data is plus-or-minus one bracket at 68-percent or plus or minus two brackets at 95-percent confidence level]

Sample number	Ash (percent)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Sample number
D183440	10.4	17	9.2	4.9	1.76	0.20	1.3	51	0.50	1.0L	D183440
D183439	10.9	21	10	6.1	3.08	.22	1.5	42	.33	1.0L	D183439
D183438	10.1	25	11	7.8	2.99	.24	1.7	36	.40	1.0L	D183438
D183437	11.1	11	4.8	7.6	2.39	.18	1.1	57	.24	1.0L	D183437
D179904	23.7	43	25	.60	1.21	.16	2.1	13	.86	1.0L	D179904
D179906	14.1	30	20	1.1	1.44	.26	1.6	27	.66	1.0L	D179906
D179905	8.1	33	22	1.9	2.12	.49	1.9	18	.77	1.0L	D179905
D176167	3.2	13	10	4.6	1.23	1.15	.51	50	.48	1.0L	D176167
D176168	17.5	47	28	.56	.96	.22	1.7	14	1.1	1.0L	D176168
D179910	5.3	9.3	5.4	22	1.34	.49	.43	23	.23	1.0L	D179910
D179909	19.7	34	18	4.4	1.13	.42	2.0	22	.60	1.0L	D179909
D183424	9.2	42	24	3.1	1.00	.24	2.3	19	1.0	1.0L	D183424
D183436	6.9	18	7.5	5.5	1.63	.54	1.4	52	.33	1.0L	D183436
D183435	6.6	31	14	6.9	2.31	.57	2.1	30	.57	1.0L	D183435
D183434	3.3	10	4.9	6.9	2.90	1.15	.81	54	.25	1.0L	D183434
D176851	4.2	29	16	4.8	2.02	.26	1.4	32	.73	1.0L	D176851
D176852	2.2	22	17	8.2	2.60	.20	.71	28	.61	1.0L	D176852
D179908	2.8	32	26	5.0	1.49	.36	1.3	12	1.4	2.4	D179908
D179907	2.8	35	30	6.1	1.14	.40	1.4	14	1.3	3.9	D179907
D176853	3.8	33	24	4.3	1.59	.31	1.7	20	1.0	1.2	D176853
D176854	3.3	37	26	4.5	1.53	.32	1.6	14	1.4	1.0L	D176854
D179903	5.1	38	28	1.9	1.23	.26	2.5	12	1.2	1.0L	D179903
D179902	2.7	30	24	4.0	1.48	.45	1.2	16	.90	1.3	D179902
D176848	4.3	13	8.9	18	4.39	1.12	.62	25	.36	1.0L	D176848
D176849	10.0	24	17	13	2.99	1.56	1.7	15	.77	1.0L	D176849
D176244	14.6	7.8	2.1	20	3.93	.61	.20	33	.11	1.0L	D176244
D176245	14.7	13	9.0	22	6.70	.84	.65	13	.29	1.0L	D176245
D176246	16.4	16	12	20	7.69	.62	.68	9.1	.32	1.0L	D176246
D176248	6.4	16	10	4.2	.96	.22	.55	51	.36	1.0L	D176248
D183433	7.7	36	22	8.7	3.50	.46	2.7	14	.72	1.0L	D183433
D183432	7.7	20	11	11	4.88	1.70	1.5	31	.57	1.0L	D183432
D183431	9.4	26	12	19	4.54	1.69	1.8	16	.74	1.0L	D183431
D176165	9.1	14	7.8	22	5.29	1.29	.68	15	.39	1.0L	D176165
D176166	10.9	16	12	21	10.0	.66	.78	9.2	.49	1.0L	D176166
D176249	5.4	20	14	2.5	1.18	.18	.92	45	.62	1.0L	D176249
D176250	14.4	40	21	1.8	1.56	.45	2.0	22	.78	1.0L	D176250
D176251	19.1	37	33	1.1	1.08	.54	2.2	8.2	.79	1.0L	D176251
D176252	12.6	42	31	2.6	1.29	1.24	1.9	5.8	1.0	1.0L	D176252
D176850	26.4	35	24	.31	.70	.18	2.1	28	.92	1.0L	D176850
D223841	17.3	12	6.8	7.3	.91	.16	.54	60	.28	.29	D223841

Table 4.--Major- and minor-oxide and trace-element composition of the laboratory ash of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	SO3 (percent)	Ag-S (ppm)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co-S (ppm)	Cr-S (ppm)	Cu (ppm)	Sample number
D183440	6.5	N	700	1,500	7	1.0	N	30	70	194	D183440
D183439	8.5	N	1,000	1,000	5	1.0L	N	15	70	110	D183439
D183438	9.8	N	1,000	1,000	5	1.0	N	15	70	67	D183438
D183437	11	N	700	1,000	7	1.5	N	15	100	50	D183437
D179904	1.3	N	150	700	10	1.0L	200	70	300	164	D179904
D179906	2.6	N	300	700	10	1.0L	200	15	300	215	D179906
D179905	4.4	N	300	700	10	1.0L	200	30	300	155	D179905
D176167	7.9	N	150	700	15	1.0L	500L	100	70	226	D176167
D176168	1.2	N	100	700	10	1.0L	500	70	150	334	D176168
D179910	11	1	200	500	1	1.0L	N	100	70	104	D179910
D179909	2.2	N	70	500	N	1.0L	N	50	150	39	D179909
D183424	2.1	N	150	300	7	1.0	500L	50	150	271	D183424
D183436	7.8	N	100	300	7	1.0L	N	200	100	52	D183436
D183435	9.1	1.5	150	300	7	1.5	500L	100	150	277	D183435
D183434	12	N	200	300	N	1.0L	N	50	30	130	D183434
D176851	8.7	N	70	700	7	1.0L	500L	200	200	165	D176851
D176852	13	1.5	70	700	15	3.5	500L	150	300	373	D176852
D179908	5.5	2	150	2,000	15	2.0L	200	150	300	668	D179908
D179907	4.9	1.5	150	3,000	15	2.0L	200	150	300	403	D179907
D176853	5.5	1	100	1,500	7	1.0	500L	150	150	301	D176853
D176854	5.3	1	100	1,500	15	1.0L	500L	150	200	632	D176854
D179903	2.9	1	70	1,500	15	1.0L	200	150	300	230	D179903
D179902	5.2	1.5	150	3,000	15	5.0	200	300	300	247	D179902
D176848	15	N	150	700	5	1.0L	N	50	70	137	D176848
D176849	15	1.5	150	700	7	1.0L	500L	70	150	193	D176849
D176244	14	N	70	200	N	1.0L	N	20	15	27	D176244
D176245	12	N	150	300	N	1.0L	N	15	70	55	D176245
D176246	13	N	100	700	N	1.0L	N	30	150	91	D176246
D176248	6.2	N	50	300	3	1.0	500L	70	70	135	D176248
D183433	10	1	150	500	10	2.0	500L	100	150	210	D183433
D183432	17	N	100	500	7	1.0L	500L	30	70	168	D183432
D183431	14	N	150	700	N	1.0L	N	15	70	92	D183431
D176165	15	1.5	150	300	N	1.0L	N	100	70	86	D176165
D176166	11	N	150	300	N	1.0L	N	30	70	105	D176166
D176249	4.1	N	70	300	3	1.0L	500L	100	70	200	D176249
D176250	3.4	N	70	500	7	1.0L	500L	30	150	106	D176250
D176251	.38	N	200	500	7	1.0L	500L	30	150	107	D176251
D176252	2.7	N	300	1,000	5	1.0L	500L	30	200	117	D176252
D176850	1.4	N	100	300	3	1.0L	500L	50	150	167	D176850
D223841	8	1L	200	500	10	1.0L	500L	15	50	97	D223841

Table 4.--Major- and minor-oxide and trace-element composition of the laboratory ash of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sample number
D183440	B	N	100L	84	422	15	30	N	150	25L	D183440
D183439	B	N	100L	60	544	30	30	150L	100	25L	D183439
D183438	B	N	N	48	710	70	30	B	150	25L	D183438
D183437	B	70	N	20	944	150	30	B	70	25L	D183437
D179904	70	N	150	176	240	20	20	200	150	50	D179904
D179906	70	N	150	118	575	20	20	150	150	45	D179906
D179905	70	N	100	175	520	15	20	150	150	55	D179905
D176167	B	N	150	37	1,100	150	20L	150	300	40	D176167
D176168	30	N	300	232	140	70	30	300	300	110	D176168
D179910	20	N	N	11	2,940	30	N	B	150	55	D179910
D179909	50	N	N	92	625	15	20	B	150	25	D179909
D183424	30	N	150	205	256	70	30	200	150	65	D183424
D183436	B	N	N	22	654	100	30	B	300	110	D183436
D183435	B	N	100L	81	1,050	70	30	150	300	70	D183435
D183434	B	N	N	14	704	30	30	B	150	25L	D183434
D176851	30	30	100L	69	1,690	70	20L	N	300	60	D176851
D176852	30	70	150	125	1,000	100	20	150	300	150	D176852
D179908	70	50	150	254	365	20	30	200	150	80	D179908
D179907	70	100	150	160	465	20	20	150	200	60	D179907
D176853	30	30	100L	171	2,000	30	20	150L	150	50	D176853
D176854	30	N	150	271	290	20	30	200	200	65	D176854
D179903	70	30	150	195	150	20	20	200	150	35	D179903
D179902	70	70	150	113	355	30	20	150	700	70	D179902
D176848	15	N	N	52	1,710	30	20L	B	70	25	D176848
D176849	30	N	100L	121	585	15	20	150L	100	45	D176849
D176244	B	N	N	10L	2,570	N	20L	B	70	25L	D176244
D176245	15	N	N	60	2,240	7	20L	B	50	25L	D176245
D176246	20	N	100L	109	2,500	10	20L	N	70	28	D176246
D176248	B	N	100L	116	2,100	15	20L	150	100	45	D176248
D183433	30	N	100L	165	296	15	30	150	300	125	D183433
D183432	20	N	100L	26	1,650	N	30	N	150	25L	D183432
D183431	15	N	100L	24	1,100	N	30	N	70	25L	D183431
D176165	20	N	N	25	2,200	10	20L	B	70	45	D176165
D176166	20	N	N	83	1,650	7	20L	B	70	25	D176166
D176249	B	N	100L	114	2,130	N	20L	N	70	40	D176249
D176250	30	N	100L	122	130	15	20L	N	100	40	D176250
D176251	30	N	100	139	80	15	20L	150L	150	45	D176251
D176252	50	N	150	220	105	15	20	150	150	50	D176252
D176850	30	N	100	185	130	15	20L	150L	100	40	D176850
D223841	20	10	70	37	744	30	30	150L	70	30L	D223841

Table 4.--Major- and minor-oxide and trace-element composition of the laboratory ash of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Sc-S (ppm)	Sr-S (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D183440	20	700	150	100	B	116	100	D183440
D183439	15	500	70	70	B	169	70	D183439
D183438	15	500	150	30	B	175	70	D183438
D183437	15	300	150	30	B	88	70	D183437
D179904	30	300	700	70	10	172	100	D179904
D179906	30	300	300	70	7	200	70	D179906
D179905	30	500	300	70	7	116	70	D179905
D176167	15	700	300	150	B	456	100	D176167
D176168	50	200	1,000	200	15	240	150	D176168
D179910	10	500	150	70	7	550	50	D179910
D179909	15	200	150	50	5	200	70	D179909
D183424	30	300	700	150	15	429	150	D183424
D183436	15	700	150	50	B	991	70	D183436
D183435	20	700	300	150	B	900	70	D183435
D183434	10L	1,000	70	50	B	454	70	D183434
D176851	30	500	300	70	7	436	150	D176851
D176852	30	1,000	700	150	15	1,970	150	D176852
D179908	30	3,000	300	150	15	191	200	D179908
D179907	30	7,000	300	70	10	650	150	D179907
D176853	30	2,000	150	70	7	1,000	150	D176853
D176854	30	1,500	300	150	15	230	300	D176854
D179903	30	1,000	300	150	15	400	150	D179903
D179902	30	3,000	300	70	10	2,200	150	D179902
D176848	15	300	70	30	5	154	70	D176848
D176849	30	300	300	70	7	155	150	D176849
D176244	N	150	30	20L	B	96	50	D176244
D176245	15	150	70	20L	3	42	70	D176245
D176246	15	500	150	30	3	148	70	D176246
D176248	15	700	150	70	B	306	70	D176248
D183433	30	70	300	200	15	1,270	100	D183433
D183432	15	70	100	70	B	576	70	D183432
D183431	15	150	150	70	7	147	100	D183431
D176165	15	150	70	30	3	800	100	D176165
D176166	15	150	100	30	3	104	100	D176166
D176249	15	300	150	70	B	232	100	D176249
D176250	30	300	150	70	7	278	150	D176250
D176251	30	300	200	50	5	204	150	D176251
D176252	30	700	300	50	5	280	150	D176252
D176850	30	300	300	70	7	117	150	D176850
D223841	15	300	150	70	5	161	100	D223841

Table 4.--Major- and minor-oxide and trace-element composition of the laboratory ash of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Ash (percent)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Sample number
D223842	16.6	19	9.5	9.8	1.79	0.24	1.2	43	0.33	0.18	D223842
D223843	13.8	9.8	6.2	13	1.71	.14	.58	47	.23	.36	D223843
D223844	27.9	49	21	3.2	1.48	.53	3.2	13	.65	.14	D223844
D223845	19.7	43	21	6.2	1.46	.36	3.0	14	.80	.10	D223845
D223846	17.7	16	7.4	14	3.27	.66	1.0	33	.32	1.0	D223846
D223847	19.9	32	15	9.5	2.26	.41	1.7	23	.42	.10	D223847
D223848	16.0	12	6.6	15	4.17	.35	.76	33	.30	.38	D223848
D223849	28.1	49	34	1.1	1.16	.68	2.2	5.1	1.0	.43	D223849
D223850	58.9	51	32	1.4	1.41	.24	2.3	3.6	1.1	.19	D223850
D223851	17.7	36	25	7.8	3.56	.84	2.0	6.7	.85	.62	D223851
D223852	13.1	24	18	15	5.37	.49	1.1	11	.57	1.1	D223852

Sample number	SO3 (percent)	Ag-S (ppm)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co-S (ppm)	Cr-S (ppm)	Cu (ppm)	Sample number
D223842	B	1L	300	1,000	7	1.0L	500L	20	70	89	D223842
D223843	B	1L	300	700	7	1.0L	500L	20	70	81	D223843
D223844	B	1L	150	1,000	7	1.0L	200	20	100	134	D223844
D223845	B	1L	200	700	10	1.0L	300	30	150	193	D223845
D223846	B	1L	150	200	5	1.0L	500L	20	50	86	D223846
D223847	B	1L	200	300	7	1.0L	500L	20	100	67	D223847
D223848	B	1L	200	300	5	1.0L	500L	30	30	51	D223848
D223849	B	1L	200	1,000	5	1.0L	200	30	200	101	D223849
D223850	B	1L	150	500	5	1.0	200	20	200	94	D223850
D223851	B	1L	200	700	5	1.0L	200	20	150	110	D223851
D223852	B	1L	150	700	5	1.0L	200	30	100	115	D223852

Table 4.--Major- and minor-oxide and trace-element composition of the laboratory ash of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sample number
D223842	30	10	70	41	664	70	30	150L	70	37	D223842
D223843	20	15	30	23	746	100	30	150L	50	46	D223843
D223844	30	7	70	105	416	20	30	150L	100	62	D223844
D223845	50	7	100	136	686	20	30	150L	150	52	D223845
D223846	15	15	50	25	1,190	30	20	150L	50	44	D223846
D223847	20	15	100	81	331	100	30	150L	150	52	D223847
D223848	15	7	70	19	868	50	30	150L	70	40	D223848
D223849	70	5	100	170	163	15	30	150L	150	53	D223849
D223850	50	5	100	175	77	7	50	150L	150	51	D223850
D223851	30	5	100	173	337	20	50	150L	100	67	D223851
D223852	20	5	70	128	449	20	20	150	100	44	D223852

Sample number	Sc-S (ppm)	Sr-S (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D223842	20	500	150	50	5	98	150	D223842
D223843	10	500	100	50	3	61	100	D223843
D223844	20	300	200	70	7	149	200	D223844
D223845	50	700	200	100	10	190	200	D223845
D223846	10	500	100	30	3	84	70	D223846
D223847	20	500	200	70	10	138	200	D223847
D223848	15	700	150	50	3	49	150	D223848
D223849	30	500	200	70	7	200	200	D223849
D223850	30	300	300	70	7	159	300	D223850
D223851	30	700	200	100	5	105	300	D223851
D223852	20	1,000	200	70	7	87	150	D223852

Table 5.--Content of seven trace elements in 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[Analyses on air-dried (32°C) coal. L, less than the value shown]

Sample number	As (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D183440	15	110	0.27	0.1	4.1	1.2	0.6	D183440
D183439	9.5	70	.14	.1	2.8	1.2	.5	D183439
D183438	9.0	55	.20	.1	2.3	1.2	2.0	D183438
D183437	7.8	65	.29	.2	2.0	.5	8.7	D183437
D179904	17	70	.34	1.2	1.9	3.0L	4.9	D179904
D179906	9.5	110	.42	.4	2.2	3.0L	3.2	D179906
D179905	7.0	60	.14	.6	.8	3.0L	1.1	D179905
D176167	30	20	.07	.3	1.4	3.0L	1.2	D176167
D176168	35	80	.34	2.7	5.2	26	13	D176168
D179910	21	20L	.06	.1	.4	3.0L	.2L	D179910
D179909	140	75	.01L	.2	2.6	3.0L	1.1	D179909
D183424	17	80	.04	.5	.8	2.7	3.8	D183424
D183436	93	50	.26	.4	2.0	.6	.2L	D183436
D183435	48	30	.11	.4	1.2	.9	.4	D183435
D183434	77	20L	.21	.1	1.1	.2	.2L	D183434
D176851	2.0	30	.02	.4	.3	3.0L	.2L	D176851
D176852	1.0L	20L	.01	.3	.5	3.0L	.2L	D176852
D179908	1.0	85	.01L	.2	.9	3.0L	.2L	D179908
D179907	.5L	90	.01L	.1L	.1	3.0L	.2L	D179907
D176853	1.0	80	.01L	.3	.7	3.0L	.3	D176853
D176854	3.0	45	.02	.2	1.2	3.0L	.5	D176854
D179903	4.5	30	.01	.3	1.1	3.0L	.2L	D179903
D179902	1.0	55	.01L	.1	.3	3.0L	.2L	D179902
D176848	1.0	30	.01L	.1L	.2	3.0L	.2	D176848
D176849	12	45	.07	.4	2.8	3.0L	.6	D176849
D176244	4.0	45	.03	.1	.5	3.0L	.2L	D176244
D176245	2.0	45	.03	.1L	.4	3.0L	.9	D176245
D176246	25	85	.12	1.4	2.0	5.0	1.3	D176246
D176248	30	85	.55	.2	2.3	3.0L	.6	D176248
D183433	6.6	65	.05	.1L	.6	1.8	.2L	D183433
D183432	6.2	50	.04	.1L	.2	1.0	.2L	D183432
D183431	7.8	85	.06	.1	.4	1.3	.6	D183431
D176165	20	25	.10	.6	.7	3.0L	.2L	D176165
D176166	4.0	25	.04	.3	.8	3.0L	.5	D176166
D176249	8.0	20L	.19	.2	1.7	3.0L	.6	D176249
D176250	20	70	.30	.5	2.0	3.0L	1.7	D176250
D176251	15	120	.21	.6	2.2	6.1	2.4	D176251
D176252	5.0	130	.04	.2	.9	3.0L	1.5	D176252
D175850	20	130	.83	.9	11	16	6.8	D176850
D223841	13	55	.35	.5	2.8	1.1	1.0	D223841

Table 5.--Content of seven trace elements in 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	As (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D223842	18	50	0.41	0.2	3.0	1.1	2.1	D223842
D223843	16	80	.45	.1	2.8	.7	4.6	D223843
D223844	58	130	.20	1.6	1.5	4.4	2.1	D223844
D223845	4.7	75	.13	.6	1.6	3.2	2.0	D223845
D223846	190	150	1.60	.2	3.7	1.0	3.7	D223846
D223847	76	80	.43	.5	2.3	2.4	.8	D223847
D223848	180	80	.65	.6	2.2	.9	1.4	D223848
D223849	7.6	240	.04	.5	1.3	5.8	3.1	D223849
D223850	6.4	360	.08	1.0	1.4	11	5.1	D223850
D223851	25	120	.11	.4	1.8	3.2	1.6	D223851
D223852	28	120	.11	.3	1.9	2.2	1.4	D223852

Table 6.--Major-, minor-, and trace-element composition of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[Values are reported on a whole-coal basis. As, F, Hg, Sb, Se, Th, and U values are from direct determinations on air-dried (32°C) coal; all other values calculated from analyses of ash. S means analysis by semiquantitative emission spectroscopy. L, less than the value shown; N, not detected; B, not determined]

Sample number	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Ti (percent)	Ag-S (ppm)	As (ppm)	Sample number
D183440	0.83	0.51	0.36	0.11	0.015	0.11	3.7	0.031	N	15	D183440
D183439	1.1	.58	.47	.20	.018	.14	3.2	.022	N	9.5	D183439
D183438	1.2	.59	.56	.18	.018	.14	2.5	.024	N	9.0	D183438
D183437	.57	.28	.60	.16	.015	.10	4.4	.016	N	7.8	D183437
D179904	4.8	3.2	.10	.17	.028	.42	2.1	.12	N	17	D179904
D179906	2.0	1.5	.11	.12	.027	.19	2.6	.056	N	9.5	D179906
D179905	1.3	.55	.11	.10	.029	.13	1.0	.037	N	7.0	D179905
D176167	.20	.18	.11	.024	.027	.014	1.1	.009	N	30	D176167
D176168	3.8	2.6	.070	.10	.029	.25	1.8	.11	N	35	D176168
D179910	.23	.15	.82	.043	.019	.019	.84	.007	.05	21	D179910
D179909	3.2	1.9	.62	.13	.061	.33	3.1	.071	N	140	D179909
D183424	1.8	1.2	.20	.055	.016	.18	1.2	.055	N	17	D183424
D183436	.58	.27	.27	.068	.028	.080	2.5	.014	N	93	D183436
D183435	.96	.49	.33	.092	.028	.12	1.4	.023	.1	48	D183435
D183434	.15	.086	.16	.058	.028	.022	1.2	.005	N	77	D183434
D176851	.57	.37	.14	.051	.008	.048	.95	.018	N	2.0	D176851
D176852	.23	.20	.13	.034	.003	.013	.43	.008	.03	1.0L	D176852
D179908	.42	.39	.10	.025	.007	.030	.23	.023	.05	1.0	D179908
D179907	.46	.44	.12	.019	.008	.033	.28	.021	.05	.5L	D179907
D176853	.59	.48	.12	.036	.009	.053	.53	.023	.03	1.0	D176853
D176854	.57	.45	.11	.030	.008	.043	.32	.027	.03	3.0	D176854
D179903	.90	.75	.070	.038	.010	.10	.43	.036	.05	4.5	D179903
D179902	.38	.35	.077	.024	.009	.028	.29	.015	.05	1.0	D179902
D176848	.27	.20	.55	.11	.036	.022	.75	.009	N	1.0	D176848
D176849	1.1	.92	.93	.18	.12	.14	1.0	.046	.15	12	D176849
D176244	.53	.16	2.1	.35	.066	.024	3.4	.010	N	4.0	D176244
D176245	.87	.70	2.3	.59	.092	.080	1.3	.026	N	2.0	D176245
D176246	1.2	1.1	2.3	.76	.075	.093	1.0	.031	N	25	D176246
D176248	.47	.35	.19	.037	.010	.029	2.3	.014	N	30	D176248
D183433	1.3	.90	.48	.16	.026	.17	.75	.033	.07	6.6	D183433
D183432	.72	.45	.60	.23	.097	.096	1.7	.026	N	6.2	D183432
D183431	1.1	.60	1.3	.26	.12	.14	1.1	.042	N	7.8	D183431
D176165	.58	.38	1.4	.29	.087	.052	.97	.021	.15	20	D176165
D176166	.83	.68	1.6	.66	.053	.071	.70	.032	N	4.0	D176166
D176249	.49	.40	.096	.038	.007	.041	1.7	.020	N	8.0	D176249
D176250	2.7	1.6	.19	.14	.048	.24	2.2	.067	N	20	D176250
D176251	3.3	3.3	.15	.12	.076	.35	1.1	.090	N	15	D176251
D176252	2.5	2.1	.23	.098	.12	.20	.51	.078	N	5.0	D176252
D176850	4.3	3.4	.058	.11	.035	.45	5.2	.15	N	20	D176850
D223841	.95	.62	.90	.095	.021	.078	7.3	.029	.15L	13	D223841

Table 6.--Major-, minor-, and trace-element composition of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--

continued

Sample number	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co-S (ppm)	Cr-S (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Sample number
DI83440	70	150	0.7	0.10	N	3	7	20	110	B	DI83440
DI83439	100	100	.5	.11L	N	1.5	7	12	70	B	DI83439
DI83438	100	100	.3	.10	N	1.5	7	6.8	55	B	DI83438
DI83437	70	100	.7	.17	N	1.5	10	5.6	65	B	DI83437
DI79904	30	150	2	.24L	50	15	70	39	70	15	DI79904
DI79906	50	100	1.5	.14L	30	2	50	30	110	10	DI79906
DI79905	20	70	.7	.08L	15	2	20	13	60	7	DI79905
DI76167	5	20	.5	.03L	15L	3	2	7.2	20	B	DI76167
DI76168	15	150	1.5	.18L	100	15	30	58	80	5	DI76168
DI79910	10	30	.05	.05L	N	5	3	5.5	20L	1	DI79910
DI79909	15	100	N	.20L	N	10	30	7.7	75	10	DI79909
DI83424	15	30	.7	.09	50L	3	15	25	80	3	DI83424
DI83436	7	20	.5	.07L	N	15	7	3.6	50	B	DI83436
DI83435	10	20	.5	.10	30L	7	10	18	30	B	DI83435
DI83434	7	10	N	.03L	N	1.5	1	4.3	20L	B	DI83434
DI76851	3	30	.3	.04L	20L	10	10	6.9	30	1.5	DI76851
DI76852	1.5	15	.3	.08	10L	3	7	8.2	20L	.7	DI76852
DI79908	5	50	.5	.06L	5	5	10	19	85	2	DI79908
DI79907	5	100	.5	.06L	5	5	10	11	90	2	DI79907
DI76853	3	70	.3	.04	20L	7	7	11	80	1	DI76853
DI76854	3	50	.5	.03L	15L	5	7	21	45	1	DI76854
DI79903	3	70	.7	.05L	10	7	15	12	30	3	DI79903
DI79902	5	70	.5	.14	5	7	7	6.7	55	2	DI79902
DI76848	7	30	.2	.04L	N	2	3	5.9	30	.7	DI76848
DI76849	15	70	.7	.10L	50L	7	15	19	45	3	DI76849
DI76244	10	30	N	.15L	N	3	2	3.9	45	B	DI76244
DI76245	20	50	N	.15L	N	2	10	8.1	45	2	DI76245
DI76246	15	100	N	.16L	N	5	20	15	85	3	DI76246
DI76248	3	20	.2	.06	30L	5	5	8.6	85	B	DI76248
DI83433	10	50	.7	.15	50L	7	10	16	65	2	DI83433
DI83432	7	50	.5	.08L	50L	2	5	13	50	1.5	DI83432
DI83431	15	70	N	.09L	N	1.5	7	8.6	85	1.5	DI83431
DI76165	15	30	N	.09L	N	10	7	7.8	25	2	DI76165
DI76166	15	30	N	.11L	N	3	2	11	25	2	DI76166
DI76249	3	15	.15	.05L	30L	5	3	11	20L	B	DI76249
DI76250	10	70	1	.14L	70L	5	20	15	70	5	DI76250
DI76251	30	100	1.5	.19L	100L	7	30	20	120	7	DI76251
DI76252	30	150	.7	.13L	70L	3	20	15	130	7	DI76252
DI76850	30	70	.7	.26L	150L	15	50	44	130	7	DI76850
D223841	50	70	1.5	.17L	100L	3	7	17	55	5	D223841

Table 6.--Major-, minor-, and trace-element composition of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Ge-S (ppm)	Hg (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	P (ppm)	Sample number
DI83440	N	0.27	10L	8.7	44	1.5	3	N	15	450L	DI83440
DI83439	N	.14	10L	6.5	59	3	3	15L	10	480L	DI83439
DI83438	N	.20	N	4.8	72	7	3	B	15	440L	DI83438
DI83437	7	.29	N	2.2	100	15	3	B	7	490L	DI83437
DI79904	N	.34	30	42	57	5	5	50	30	1,000L	DI79904
DI79906	N	.42	20	17	81	3	3	20	20	620L	DI79906
DI79905	N	.14	7	14	42	1.5	1.5	15	15	350L	DI79905
DI76167	N	.07	5	1.2	35	5	.7L	5	10	140L	DI76167
DI76168	N	.34	50	41	25	15	5	50	50	760L	DI76168
DI79910	N	.06	N	.6	160	1.5	N	B	7	230L	DI79910
DI79909	N	.01L	N	18	120	3	5	B	30	860L	DI79909
DI83424	N	.04	15	19	24	7	3	20	15	400L	DI83424
DI83436	N	.26	N	1.5	45	7	2	B	20	300L	DI83436
DI83435	N	.11	7L	5.3	69	5	2	10	20	290L	DI83435
DI83434	N	.21	N	.5	23	1	1	B	5	140L	DI83434
DI76851	1.5	.02	5L	2.9	71	3	1L	N	15	180L	DI76851
DI76852	1.5	.01	3	2.8	22	2	.5	3	7	96L	DI76852
DI79908	1.5	.01L	5	7.1	10	.5	1	5	5	290	DI79908
DI79907	3	.01L	5	4.5	13	.5	.5	5	5	480	DI79907
DI76853	1	.01L	3L	6.5	76	1	.7	7L	7	200	DI76853
DI76854	N	.02	5	8.9	9.6	.7	1	7	7	140L	DI76854
DI79903	1.5	.01	7	9.9	7.7	1	1	10	7	220L	DI79903
DI79902	2	.01L	5	3.1	9.6	.7	.5	5	20	150	DI79902
DI76848	N	.01L	N	2.2	74	1.5	1L	B	3	190L	DI76848
DI76849	N	.07	10L	12	58	1.5	2	15L	10	440L	DI76849
DI76244	N	.03	N	1.5L	380	N	3L	B	10	640L	DI76244
DI76245	N	.03	N	8.8	330	1	3L	B	7	640L	DI76245
DI76246	N	.12	15L	18	410	1.5	3L	N	10	720L	DI76246
DI76248	N	.55	7L	7.4	130	1	1.5L	10	7	280L	DI76248
DI83433	N	.05	7L	13	23	1	2	10	20	340L	DI83433
DI83432	N	.04	7L	2.0	130	N	2	N	10	340L	DI83432
DI83431	N	.06	10L	2.3	100	N	3	N	7	410L	DI83431
DI76165	N	.10	N	2.3	200	1	2L	B	7	400L	DI76165
DI76166	N	.04	N	9.0	180	.7	2L	B	7	480L	DI76166
DI76249	N	.19	5L	6.2	120	N	1L	N	3	240L	DI76249
DI76250	N	.30	15L	18	19	2	3L	N	15	630L	DI76250
DI76251	N	.21	20	27	15	3	3L	30L	30	830L	DI76251
DI76252	N	.04	20	28	13	2	2	20	20	550L	DI76252
DI76850	N	.83	30	49	34	5	5L	50L	30	1,200L	DI76850
D223841	1.5	.35	10	6.4	130	7	5	20L	15	220	D223841

Table 6.--Major-, minor-, and trace-element composition of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--

continued

Sample number	Pb (ppm)	Sb (ppm)	Sc-S (ppm)	Se (ppm)	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Sample number
D183440	2.6L	0.1	2	4.1	70	1.2	0.6	15	10	B	D183440
D183439	2.7L	.1	1.5	2.8	50	1.2	.5	7	7	B	D183439
D183438	2.5L	.1	1.5	2.3	50	1.2	2.0	15	5	B	D183438
D183437	2.8L	.2	1.5	2.0	30	.5	8.7	15	3	B	D183437
D179904	12	1.2	7	1.9	70	3.0L	4.9	150	15	2	D179904
D179906	6.3	.4	5	2.2	50	3.0L	3.2	50	10	1	D179906
D179905	4.5	.6	2	.8	50	3.0L	1.1	20	7	.7	D179905
D176167	1.3	.3	.5	1.4	20	3.0L	1.2	10	5	B	D176167
D176168	19	2.7	10	5.2	30	26.0	13	150	30	3	D176168
D179910	2.9	.1	.5	.4	30	3.0L	.2L	7	3	.3	D179910
D179909	4.9	.2	3	2.6	50	3.0L	1.1	30	10	1	D179909
D183424	6.0	.5	3	.8	30	2.7	3.8	70	15	1.5	D183424
D183436	7.6	.4	1	2.0	50	.6	.2L	10	3	B	D183436
D183435	4.6	.4	1.5	1.2	50	.9	.4	20	10	B	D183435
D183434	.8L	.1	.3L	1.1	30	.2	.2L	2	1.5	B	D183434
D176851	2.5	.4	1.5	.3	20	3.0L	.2L	15	3	.3	D176851
D176852	3.3	.3	.7	.5	20	3.0L	.2L	15	3	.3	D176852
D179908	2.2	.2	1	.9	100	3.0L	.2L	10	5	.5	D179908
D179907	1.7	.1L	1	.1	200	3.0L	.2L	10	2	.3	D179907
D176853	1.9	.3	1	.7	70	3.0L	.3	7	3	.3	D176853
D176854	2.1	.2	1	1.2	50	3.0L	.5	10	5	.5	D176854
D179903	1.8	.3	1.5	1.1	50	3.0L	.2L	15	7	.7	D179903
D179902	1.9	.1	.7	.3	70	3.0L	.2L	7	2	.3	D179902
D176848	1.1	.1L	.7	.2	15	3.0L	.2	3	1.5	.2	D176848
D176849	4.5	.4	3	2.8	30	3.0L	.6	30	7	.7	D176849
D176244	3.7L	.1	N	.5	20	3.0L	.2L	5	3L	B	D176244
D176245	3.7L	.1L	2	.4	20	3.0L	.9	10	3L	.5	D176245
D176246	4.6	1.4	2	2.0	70	5.0	1.3	20	5	.5	D176246
D176248	2.9	.2	1	2.3	50	3.0L	.6	10	5	B	D176248
D183433	9.6	.1L	2	.6	5	1.8	.2L	20	15	1	D183433
D183432	1.9L	.1L	1	.2	5	1.0	.2L	7	5	B	D183432
D183431	2.4L	.1	1.5	.4	15	1.3	.6	15	7	.7	D183431
D176165	4.1	.6	1.5	.7	15	3.0L	.2L	7	3	.3	D176165
D176166	2.7	.3	1.5	.8	15	3.0L	.5	10	3	.3	D176166
D176249	2.2	.2	.7	1.7	15	3.0L	.6	7	3	B	D176249
D176250	5.8	.5	5	2.0	50	3.0L	1.7	20	10	1	D176250
D176251	8.6	.6	7	2.2	70	6.1	2.4	30	10	1	D176251
D176252	6.3	.2	3	.9	100	3.0L	1.5	30	7	.7	D176252
D176850	11	.9	7	11	70	16.0	6.8	70	20	2	D176850
D223841	5.2L	.5	2	2.8	70	1.1	1.0	20	15	1	D223841

Table 6.--Major-, minor-, and trace-element composition of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Zn (ppm)	Zr-S (ppm)
D183440	12	10
D183439	18	7
D183438	18	7
D183437	9.8	7
D179904	41	20
D179906	28	10
D179905	9.4	7
D176167	15	3
D176168	42	30
D179910	29	3
D179909	39	15
D183424	39	15
D183436	68	5
D183435	59	5
D183434	15	2
D176851	18	7
D176852	43	3
D179908	5.3	5
D179907	18	5
D176853	38	7
D176854	7.6	10
D179903	20	7
D179902	59	5
D176848	6.6	3
D176849	16	15
D176244	14	7
D176245	6.2	10
D176246	24	10
D176248	20	5
D183433	97	7
D183432	44	5
D183431	14	10
D176165	73	10
D176166	11	10
D176249	13	5
D176250	40	20
D176251	39	30
D176252	35	20
D176850	31	50
D223841	28	20

Table 6.--Major-, minor-, and trace-element composition of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Ti (percent)	Ag-S (ppm)	As (ppm)	Sample number
D223842	1.5	0.83	1.2	0.18	0.030	0.17	5.0	0.033	0.15L	18	D223842
D223843	.63	.46	1.3	.14	.014	.046	4.6	.019	.15L	16	D223843
D223844	6.4	3.1	.64	.25	.11	.75	2.5	.11	.3L	58	D223844
D223845	3.9	2.2	.87	.17	.053	.49	1.9	.095	.2L	4.7	D223845
D223846	1.3	.69	1.8	.35	.087	.15	4.1	.034	.15L	190	D223846
D223847	3.0	1.6	1.4	.27	.060	.28	3.2	.050	.2L	76	D223847
D223848	.90	.56	1.8	.40	.042	.10	3.7	.029	.15L	180	D223848
D223849	6.5	5.1	.22	.20	.14	.51	1.0	.17	.3L	7.6	D223849
D223850	14	10	.57	.50	.11	1.1	1.5	.38	.7L	6.4	D223850
D223851	3.0	2.3	.99	.38	.11	.30	.83	.090	.15L	25	D223851
D223852	1.4	1.2	1.4	.42	.047	.12	1.0	.045	.15L	28	D223852

Sample number	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co-S (ppm)	Cr-S (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Sample number
D223842	50	150	1.5	0.17L	100L	3	15	15	50	5	D223842
D223843	50	100	1	.14L	70L	2	7	11	80	3	D223843
D223844	50	200	2	.28L	50	7	30	37	130	10	D223844
D223845	50	150	2	.20L	50	7	30	38	75	7	D223845
D223846	30	50	1	.18L	100L	5	7	15	150	3	D223846
D223847	50	70	1.5	.20L	100L	5	20	13	80	5	D223847
D223848	50	50	.7	.16L	70L	5	7	8.2	80	2	D223848
D223849	70	200	1.5	.28L	70	10	70	28	240	15	D223849
D223850	100	300	3	.59	150	15	150	55	360	30	D223850
D223851	50	100	1	.18L	50	5	20	19	120	7	D223851
D223852	20	100	.7	.13L	30	5	15	15	120	3	D223852

Table 6.--Major-, minor-, and trace-element composition of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Ce-S (ppm)	Hg (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	P (ppm)	Sample number
D223842	2	0.41	10	6.8	110	15	5	20L	10	130	D223842
D223843	2	.45	5	3.2	100	15	5	20L	7	220	D223843
D223844	2	.20	20	29	120	7	10	50L	30	170	D223844
D223845	1.5	.13	20	27	140	5	7	30L	30	88	D223845
D223846	3	1.6	10	4.4	210	5	5	30L	10	790	D223846
D223847	3	.43	20	16	66	20	7	30L	30	88	D223847
D223848	1.5	.65	10	3.0	140	7	5	20L	15	260	D223848
D223849	1	.04	30	48	46	3	10	50L	50	520	D223849
D223850	3	.08	70	100	45	5	30	100L	70	480	D223850
D223851	.7	.11	15	31	60	3	7	30L	20	480	D223851
D223852	.7	.11	10	17	59	3	3	15	15	660	D223852

Sample number	Pb (ppm)	Sb (ppm)	Sc-S (ppm)	Se (ppm)	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Sample number
D223842	6.1	0.2	3	3.0	70	1.1	2.1	20	10	0.7	D223842
D223843	6.3	.1	1.5	2.8	50	.7	4.6	15	7	.5	D223843
D223844	17	1.6	7	1.5	100	4.4	2.1	50	15	2	D223844
D223845	10	.6	7	1.6	100	3.2	2.0	50	20	2	D223845
D223846	7.8	.2	1.5	3.7	100	1.0	3.7	20	7	.7	D223846
D223847	10	.5	5	2.3	100	2.4	.8	50	15	1.5	D223847
D223848	6.4	.6	2	2.2	100	.9	1.4	20	7	.5	D223848
D223849	15	.5	10	1.3	150	5.8	3.1	70	15	2	D223849
D223850	30	1.0	20	1.4	200	11.0	5.1	150	50	3	D223850
D223851	12	.4	7	1.8	150	3.2	1.6	50	15	1	D223851
D223852	5.8	.3	3	1.9	150	2.2	1.4	30	10	.7	D223852

Table 6.--Major-, minor-, and trace-element composition of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma--continued

Sample number	Zn (ppm)	Zr-S (ppm)
D223842	16	20
D223843	8.4	15
D223844	42	50
D223845	37	50
D223846	15	15
D223847	27	50
D223848	7.8	30
D223849	56	70
D223850	94	150
D223851	19	70
D223852	11	20

Table 7.--Elements looked for but not detected in coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[Approximate lower detection limits in ash, as determined by the six-step spectrographic method of the U.S. Geological Survey, are included for all elements]

Element name	Symbol	Lower limit of detection in ash (ppm)
Gold	Au	50
Bismuth	Bi	20
Dysprosium	Dy	100
Erbium	Er	100
Europium	Eu	200
Gadolinium	Gd	100
Hafnium	Hf	200
Holmium	Ho	50
Indium	In	20
Lutetium	Lu	70
Palladium	Pd	5
Praseodymium	Pr	200
Platinum	Pt	100
Rhenium	Re	100
Samarium	Sm	200
Tin	Sn	20
Tantalum	Ta	1,000
Terbium	Tb	700
Tellerium	Te	5,000
Thallium	Tl	100
Thulium	Tm	50
Tungsten	W	200

Table 8.—Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, and heat of combustion, forms of sulfur, and ash-fusion temperatures of 30 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[All values are in percent except kcal/kg, Btu/lb, and ash-fusion temperatures, and are reported on the as-received basis. °F = (°C x 1.8) + 32; kcal/kg = 0.556 x (Btu/lb). Leaders (——) indicate no data. For comparison, geometric means for 90 Interior province coal samples (Swanson and others, 1976, table 16a) are included]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Interior province geometric deviation
		Minimum	Maximum			
Proximate and ultimate analyses						
Moisture	2.1	1.0	4.9	2.0	1.4	5.9
Volatile matter	26.3	13.9	38.9	25.1	1.4	30.9
Fixed carbon	59.1	28.0	75.5	57.4	1.3	46.3
Ash	13.2	2.6	56.0	10.3	2.0	10.7
Hydrogen	4.6	2.7	5.2	4.5	1.2	4.9
Carbon	72.8	33.2	85.7	71.6	1.2	64.3
Nitrogen	1.6	.7	2.1	1.6	1.2	1.2
Oxygen	5.5	2.2	9.6	5.3	1.4	10.7
Sulfur	2.5	.5	9.1	1.9	2.2	3.0
Heat of combustion						
Kcal/kg	7,170	3,130	8,320	7,050	1.2	6,360
Btu/lb	12,900	5,620	14,960	12,960	1.2	11,440
Forms of sulfur						
Sulfate	0.17	0.01	0.49	0.09	3.1	0.11
Pyritic	1.96	.02	7.26	.74	4.1	1.49
Organic	.75	.07	2.42	.59	2.0	1.05
Ash-fusion temperatures, °C						
Initial deformation	1,150	965	1,445	1,145	1.1	——
Softening temperature	1,200	1,040	1,500	1,195	1.1	——
Fluid temperature	1,250	1,075	1,540+	1,245	1.1	——

Table 9.—Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of nine major and minor oxides in the laboratory ash of 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[All samples were ashed at 525°C; all values except geometric deviation are in percent. For comparison, geometric means for 155 Interior province coal samples (Hatch and Swanson, 1977, table 4a) are included]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Interior province geometric mean
		Minimum	Maximum			
(Ash)	12.9	2.2	58.9	9.8	2.1	12.9
SiO_2	27	7.8	51	24	1.7	24
Al_2O_3	17	2.1	34	14	1.9	11
CaO	9.2	.31	22	5.4	2.8	5.4
MgO	2.5	.70	10.0	2.07	1.9	.81
Na_2O	.54	.14	1.70	.43	2.0	.27
K_2O	1.5	.20	3.2	1.3	1.8	.99
Fe_2O_3	26	3.6	60	20	2.0	26
TiO_2	.66	.11	1.4	.56	1.8	.54
SO_3	8.6	.38	17	5.9	2.4	4.8

Table 10.—Arithmetic mean, observed range, geometric mean, and geometric deviation of 34 elements in 51 coal samples from the Krebs Group, Arkoma basin, eastern Oklahoma

[All analyses are in percent or parts per million and are reported on a whole-coal basis. L, less than the value shown. For comparison, geometric means for 155 Interior province coal samples (Hatch and Swanson, 1977, table 4b) are included]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Interior province geometric mean
		Minimum	Maximum			
			Percent			
Si	1.8	0.15	14	1.1	2.7	1.4
Al	1.2	.086	10	.74	2.7	.77
Ca	.70	.058	2.3	.38	3.1	.50
Mg	.19	.019	.76	.12	2.6	.063
Na	.048	.003	.14	.031	2.6	.026
K	.18	.013	1.1	.10	2.9	.11
Fe	2.0	.23	7.3	1.4	2.3	2.3
Ti	.048	.005	.38	.033	2.4	.040
			Parts per million			
As	30	0.5L	190	11	4.2	12
B	30	1.5	100	15	3.0	50
Ba	70	10	300	50	2.1	30
Be	1	.05	3	.5	4.0	1.5
Co	7	1.5	15	5	2.0	7
Cr	15	1	150	10	2.6	10
Cu	16	3.6	58	13	1.9	16
F	78	20L	360	61	2.0	58
Ga	5	.7	30	3	2.4	3
Hg	.26	.01L	1.6	.08	4.6	.10
Li	16	.5	100	7.4	3.5	7.0
Mn	95	7.6	410	59	2.7	72
Mo	5	.5	20	3	3.1	2
Nb	3	.5	30	1.5	4.2	.7
Ni	15	3	70	15	2.0	20
Pb	6.1	.8L	30	3.3	3.1	19
Sb	.4	.1L	2.7	.3	2.4	.8
Sc	3	.3L	20	2	2.5	3
Se	1.9	.1	11	1.2	2.5	2.8
Sr	70	5	200	50	2.3	30
U	2.1	.2L	13	.7	4.3	1.4
V	30	2	150	20	2.6	20
Y	10	1.5	50	7	2.3	7
Yb	1	.2	3	.7	2.0	.7
Zn	30	5.4	98	23	2.1	58
Zr	20	2	150	10	2.6	10